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The risk analysis of dangerous cargo docks of Zhenjiang section of Yangtze River

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The Risk Analysis of Dangerous Cargo Docks of Zhenjiang Section of Yangtze River

By

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The People's Republic of China

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

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sincere gratitude to my colleagues from Zhenjiang MSA who helped me work out my problems during the difficult course of the thesis.

Abstract

Title of Research Paper: **The Risk Analysis of Dangerous Cargo Docks of Zhenjiang Section of Yangtze River**

Degree: **Msc**

The risk evaluation research of China started in the 1980s, and refers to foreign research results mainly. So at present, there is not a perfect set of procedures and methods suitable for China about the risk evaluation.

The dangerous cargo docks are the infrastructures with risk due to their particularity，meanwhile, the safety of the dangerous cargo docks impacts not only on the Water transport but also on the local environment and economic development as well as the safety and health of the residents in the neighboring area.

So, it is necessary to apply the risk evaluation theory in the management of dangerous cargo docks, especially in the inland rivers, and then evaluate the security of the dangerous cargo docks through the establishment of the Safety evaluation index system, provide some methods to increase the management level of the dangerous cargo docks.

In this essay, the dangerous cargo docks of Zhenjiang section of Yangtze River will be taken as an example to analyze the current situation and management situation of the dangerous cargo docks deeply and the risk and problems will be pointed out. Moreover, the pollution risk will be calculated in this essay with the Risk Matrix on the basis of the research results of the risk rating and the local physical truth,

especially that the sensitive water region and sensitive contaminant will also be evaluated to provide the maritime administration measures to keep the safety of the docks and the environment.

Keywords: Risk Analysis, Dangerous Cargo Docks, Pollution Accidents, Measures

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LIST OF ABBREVIATIONS

ARM	Associate in risk Management
DWT	Dead Weight Tons
IMO	International Maritime Organization
MSA	Maritime Safety Administration
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
UK	United Kingdom
US	United States
VHF	Very High Frequency
VTS	Vessel Traffic Service

Chapter 1 Introduction

1.1 Research background

The manufacturing industry is transferring to the boo-ay and mid-west area of China along with the rise of central China and the development of the west. So the Yangtze River is becoming an increasingly important source of economic development and playing a more and more important role in the national economic development. Inland water transport not only has the advantages such as higher transportation capacity, environmentally friendliness and lower cost but also has the characters for instance that, the kind's amount and complicated character. Once the accident happens, it is difficult to rescue and modify the environment due to the sudden, diffusion speed and influence range of the accident.

In recent years, the pollution accidents never stop happening, and they do not only cause the significant casualties and economic loss but also cause important social consequences. For example, on April 4, 2002, the styrene of M/T WOOTHER leaked in CHIMEI port, causing the whole downstream to be out of water supply; on August 11, 2009, 62 containers including 12 dangerous cargo containers fell into the Yangtze River because of the slant when the vessel was navigating in the Yichang section. Although the Yangtze River was not polluted, the incident sounded an alarm to the administration.

The safety problems are a matter of primary importance of the governments and the management of the transportation, production and store of the dangerous cargo has been classified as the emphasis of the public security. The ministry of transport safety supervision has issued the “waterway transportation emergency plan” to improve the emergency disposal capability of the managers with the purpose of dealing with the emergency effectively. In the September of 2009, the MSA incepted potential safety hazards of the dangerous cargo docks. And all the above measures improved the management level of the store and transportation of the dangerous cargo and the reliability of the security facilities. In addition the measures played a positive role in preventing the accidents.

1.2 The purpose and significance of the research

A port enterprise equipped with new technology should have modern safety managerialics, and should establish risk evaluation system to convert the tradition passive accident management to the modern potential risk management.

So the main purpose of this essay is to find out the weak link of the safety management trough the risk source analysis and a series of methods and to help the ports reduce the risk level and to improve the safety.

1.3 The significance of the research

At present, most of the risk evaluations of dangerous cargo dock are in the beginning of the docks, however, the facilities will abrasion along with the use and the risk evaluations can not reflect the physical truth. What’s more, there are few of the

evaluations in operation. Therefore, the evaluations should be continuously to analysis of the risk level, safety status and reasons of the accidents.

Moreover, the qualitative evaluation method is used in most of the risk evaluations of the dangerous docks, and it cannot meet the management requires of port enterprises due to the scattered property of the evaluation indicators.

So, the risk matrix method will be applied in this essay to analyze the risk of dangerous cargo docks in the Zhenjiang section of Yangtze River in order to find out the weak link and to provide new ideas about the measures of promoting of the sustainable development of the economy and society.

Chapter 2 Evaluation Content

2.1 Status analysis

Status analysis means that collecting files for instance Production & safety operations, Pollution prevention management status, and local environment information such as water area, zoology, fishery resources and other environmentally sensitive resources, and then analyze the status of dangerous cargo transport on the basis of the local economic conditions and port development program.

2.2 Risk identification

This part of the essay will analyze and identify the accident sources, risk types, criticality according to the statistic analysis of the previous accidents and the research of the typical cases, and then confirm the main risk resource on the basis of the analysis of the hazardous characteristics of the dangerous cargo and the statistical data of the handling technology.

2.3 Source analysis

This part of the essay will predictively parse the probability and the scale of the pollution incidents in the operation procedure, according to the traffic flow,

dangerous cargo volume, and historical statistics of the ship pollution incidents of Zhenjiang section of Yangtze River, with the purpose of forecasting pollution incident risk forecast and the determining the source of maximum pollution incident.

2.4 Risk evaluation

This part of the essay will evaluate the level of sensitivity of Regional social economy and environment in the view of pollutant amount and pollutant type to analyze the hazard consequence.

2.5 Evaluation results

This part will evaluate the risk level with the Matrix method on the basis of the collected data.

2.6 Countermeasures to reduce the risk

This part will provide the countermeasures to prevent the pollution incident hazards according to the results of the risk analysis and pollution impact prediction. Meanwhile, this part will also provide an Emergency facilities plan of Zhenjiang section of the Yangtze River on the basis of the local laws, standards and regulations to meet the requirements of the prevention of pollution incidents within the Zhenjiang section of the Yangtze River.

Chapter 3 Status analysis

3.1 Basic introduction

3.1.1 Geography conditions

Zhenjiang Port is located at the south bank of lower reaches of Yangtze River, where the Beijing-Hangzhou Grand Canal crosses the Yangtze River. Zhenjiang port is 87km from Nanjing and 279 km from the estuary, and it owns 270km natural shoreline including 87km deep water shoreline.

As a result, the traffic lines of Zhenjiang Port radiate in all directions and the "seamless joint" can be realized here. The Zhenjiang Port is not only one of the important hubs of the Comprehensive transportation system of Yangtze River Delta but also a main Transshipment port of energy resources and raw materials along the Yangtze River.

According to the "overall planning of Zhenjiang port", Zhenjiang Port will develop into a comprehensive and modern port on the raw materials transportation, energy transportation and container transportation and has functions such as water-land transit shipment, store, modern logistics, and bonded processing.

Figure 3.1 - Geography location of Zhenjiang section of Yangtze River.

Source: Internet Map **(http://www.heremaps.com)**

3.1.2 Weather conditions

3.1.2.1 Weather

The Zhenjiang section of Yangtze River is in the monsoon climate zone of the north humid tropics. The place enjoys a temperate climate with well-marked seasons with plenty of rainfall and sunshine.

(a) Temperature

Annual average temperature: 15.3℃;

Average temperature of the hottest months: 28.2 ℃;

Extremely highest temperature： 41.1 ℃;

Average temperature of the coldest months： 2.7℃;

Extremely lowest temperature: -12.9℃.

(b)Rainfall

Annual maximum rainfall: 1815mm;

Annual maximum rainfall: 1043.8mm;

Annual average rainfall days: 119.7 days;

Monthly maximum rainfall: 535.7mm;

Daily maximum rainfall: 196.3mm;

Daily rainfall greater than or equal to 5mm: for 52 days;

Daily rainfall greater than or equal to 25mm: for 12 days;

The maximum depth of snow: 22cm;

The maximum depth of frozen soil: 12cm.

(c)Wind regime

Predominant wind direction: Wind in the winter is mainly northeaster, the frequency is 9% and in the spring and summer the Predominant wind direction is southeaster, the frequency is 19%;

Annual average wind speed: 2.9m/s;

Maximum wind speed: 31m/s;

The average annual days greater than force 7 wind: 6 ~ 19 days.

(d) Fog condition

The average annual fog days of Zhenjiang section of Yangtze River is 26 days, almost in autumn and winter. The average monthly fog day is 3 to 6 days. Visibility is more than level three, the fog is short meanwhile it often starts early in the morning, and abreaction happens around 9 am, so there is little impact on ship navigation.

3.1.3 Navigation condition

3.1.3.1 Channel condition

The natural shoreline of Zhenjiang section of Yangtze River is about 270km which includes 87km deep, water shoreline. And according to the plan, 130.3km shoreline will be used as the port shoreline.

The channel of Zhenjiang section is made up of Yizheng water channel, Jiaoshan water channel, Dantu straight water channel, Kouan water channel and Taixing water channel. The perennial Dredging Depth is about 10.5m and the width of the water channel is around 500m. But the navigation condition is extremely complicated, especially within the regions near the Yingongzhou One-way traffic control section. The width of Yingongzhou One-way traffic control section is only about 200m, and at the same time, the vessels which pass here have to face two consecutive 90 degree bends. Moreover, Beijing-Hangzhou Grand Canal crosses the Yangtze River in Yingongzhou One-way traffic control section, so numerous inland river ships which are small size would also cross the Yangze River in this section, making nacigation condition poor.

3.1.3.2 The ship route and navigation methods

All the vessels which navigate in the Zhenjiang section of Yangtze River have to obey the "vessel routing system of Jiangsu section of Yangtze River" which was implemented on July 1st 2003. The routing system follows the regulations as follows：

(a) Separation of large and small-sized vessels.
(b) Avoiding the Cross route.
(c) Navigation in the right.

(d) Principle of liability for fault.

3.1.4 Status of dangerous cargo docks in Zhenjiang section of Yangtze River

There are 9 dangerous cargo docks and 20 berths in Zhenjiang section of Yangtze River. In 2013, 83 sorts, a total of 7.46million tons dangerous cargo were transferred here.

In the recent 5 years, the dangerous cargo transport volume has developed steadily, from 6.574 million tons in 2009 to 14.5millon tons in 2013.

3.1.4.1 The statistics about the dangerous cargo transferred by the vessel

a. Freight volumes according to the annual statistics

Table 3.1 - Freight volumes according to the annual statistics.

Year	2009	2010	2011	2012	2013
Freight volume （million tons）	6.574	6.527	7.508	9.464	14.50
Growth rate（+/-）	9.3%	-0.71%	15.03%	26.05%	53.21%

Source: Data provided by the Department of Dangerous Cargo Management and Pollution Prevention of Zhenjiang MSA.

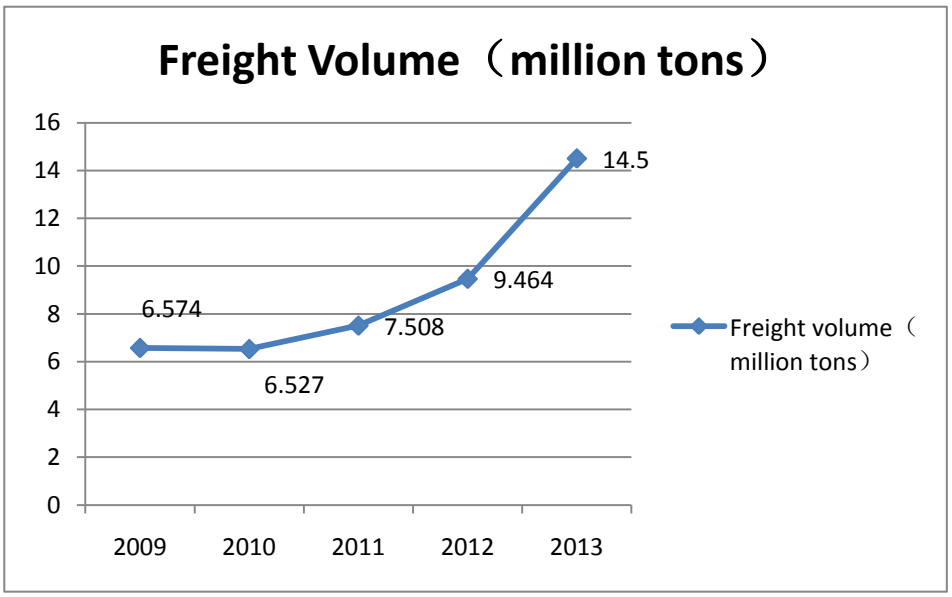

Figure 3.2 - Freight volumes according to the annual statistics.

Source: Compiled by the author based on basic data.

Table 3.1 and Figure 3.2 illustrate the freight volume of dangerous cargo within Zhenjiang section of Yangtze River, we can see from the chart that the growth of the freight volume was rapid in 2011 and 2012, it was about 20%. However, the freight volume grew slowly, only less than 10% in 2009 and 2010. According to other statistics, we can find the reason for the rapid growth in 2011. Oil transportation volume growth caused by oil demand of petrochemical enterprises rose greatly.

The growth of freight volume in 2013 was caused by normalizing and updating of vessel cargo and passengers, electronic declaration system. A total of 50% of the dangerous cargo was the bulk solid dangerous cargo.

b. Freight volume according to the category statistics

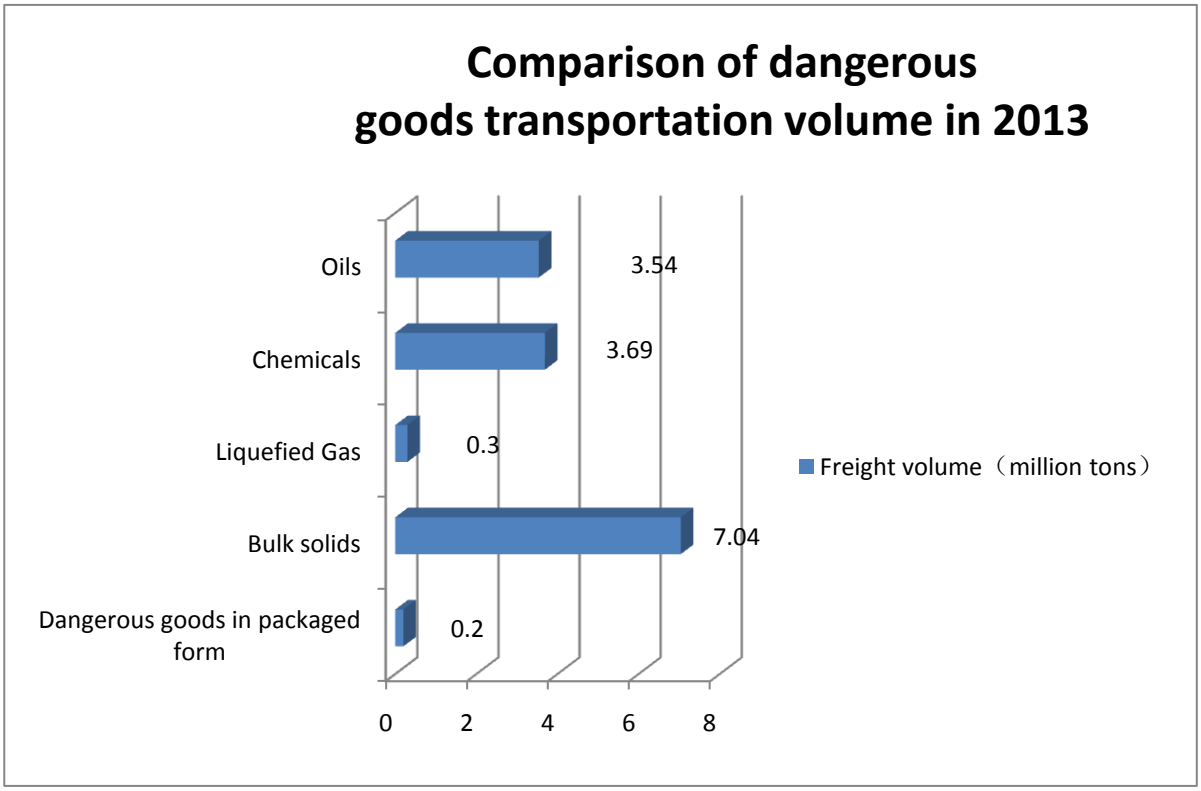

Figure 3.3 - Freight volume according to the category statistics.

Source: Compiled by the author based on basic data

① Comparison of dangerous cargo transportation volume in 2013.

It can be clearly seen from the chart above that the dangerous cargo transferred in Zhenjiang section of Yangtze River were mainly chemicals (25.5%), oils (24.4%) and bulk solids (48.5%), however,only1.2% of the dangerous goods were liquefied while 1.4% were in packaged form.

② Statistics about the bulk chemicals and oils transferred volume in Zhenjiang section of Yangtze River in recent 5 years.

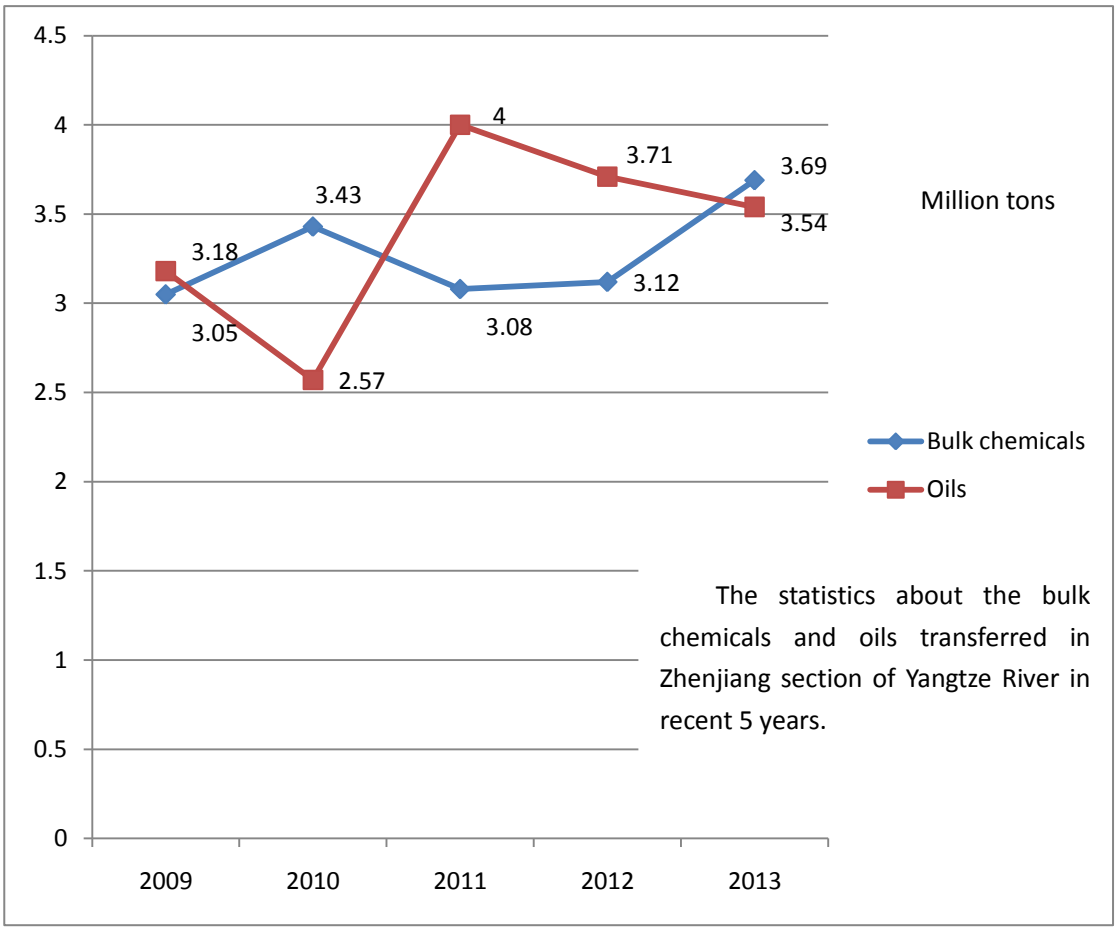

Figure 3.4 - Statistics about the bulk chemicals and oils transferred volume in Zhenjiang section of Yangtze River in recent 5 years.

Source: Compiled by the author based on basic data.

It can be seen from the chart that, the overall trend of transport volume of bulk chemicals was steady in recent 5 years, it rose up from 3.18 million tons in 2009 to 3.69 million tons in 2013. However the transport volume of oils fluctuated obviously. It decreased to the 2.57 million tons in 2010 and but peaked 4 million tons in 2011, with the growth rate of more than 50%, and then dropped to 3.54 million tons in 2013.

③ Freight volume statistics according to different deadweight ton vessels in 2013.

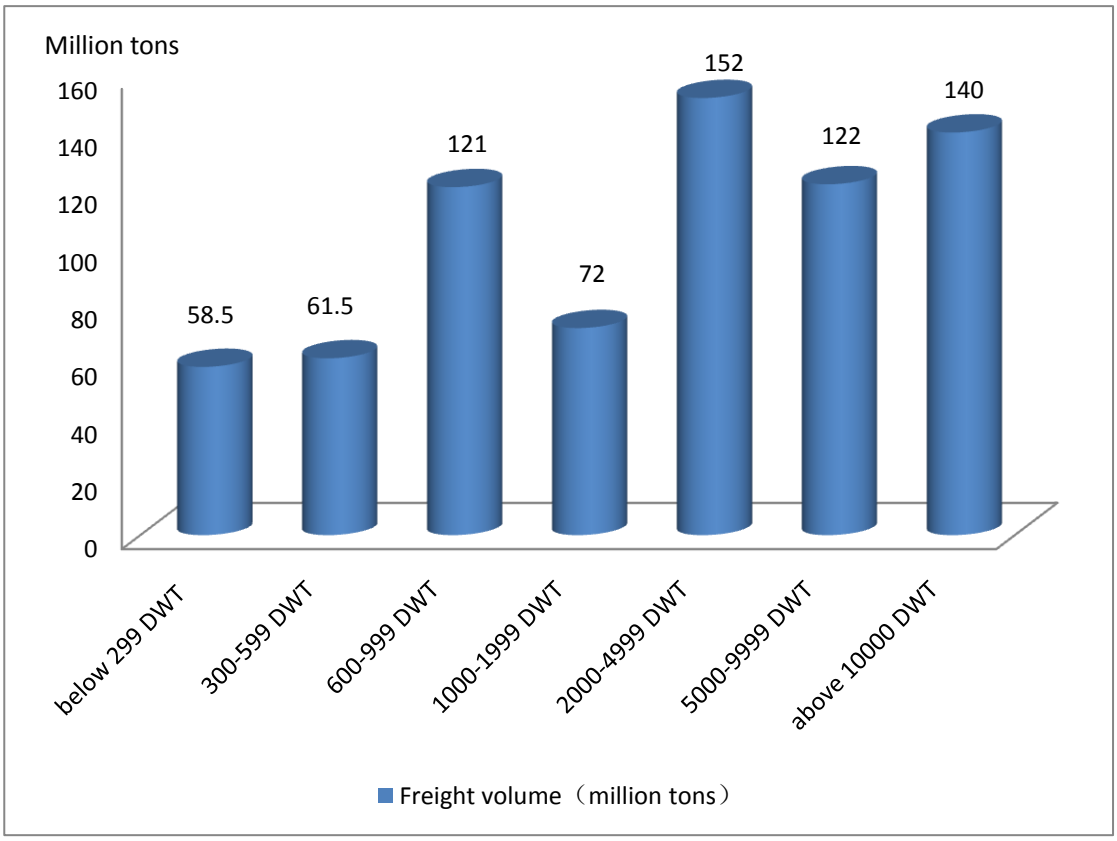

Figure 3.5 - Freight volume statistics according to different deadweight ton vessels in 2013.

Source: Compiled by the author based on basic data.

It can be seen from the Figure 3.5 that the vessels with more than 2000 DWT was the mainstream of the tankers transfering dangerous cargo in Zhenjiang section of Yangtze River. More than 57% of the dangerous cargo was transferred by them, almost the same in 2012.

④ Statistics about the Category XY substance

Year	ships	Freight volume（ton）

2009	155	475182
2010	166	554550
2011	192	720000
2012	201	762310
2013	215	920142

Table 3.2 - Statistics about the Category XY substance in different years

Source: Data provided by the Department of Dangerous Cargo Management and Pollution Prevention of Zhenjiang MSA.

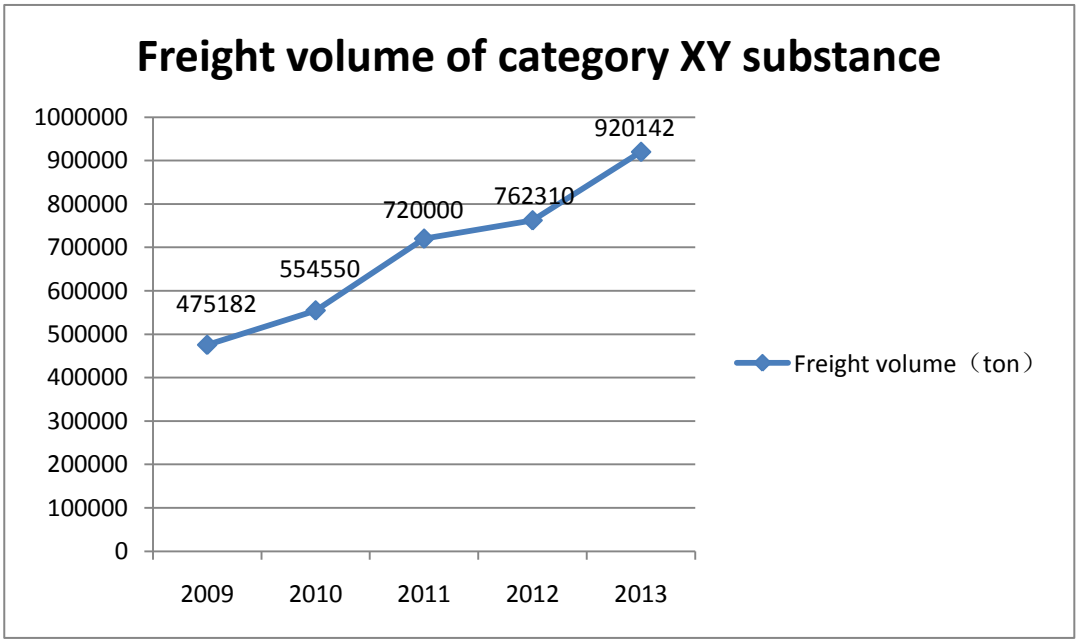

Figure 3.6 - Freight volume of category XY substance.

Source: Compiled by the author based on basic data.

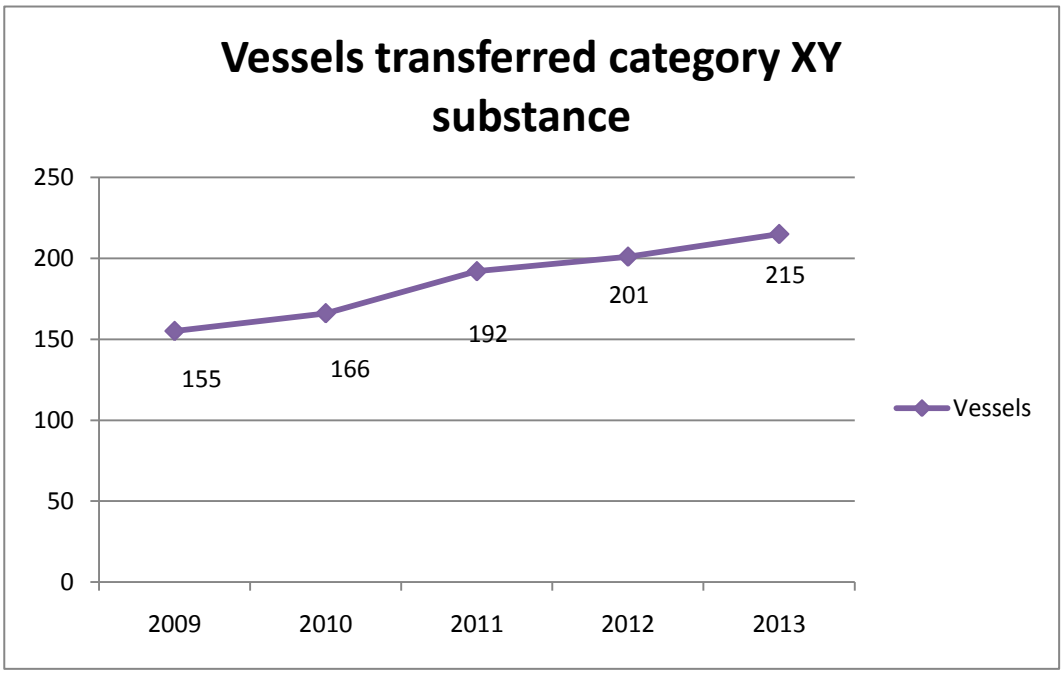

Figure 3.7 - Vessels volume of category XY substance.

Source: Compiled by the author based on basic data.

As can be seen from the above charts both the number of the vessels and the freight volume have increased steadily in the recent 5 years. The average annual growth rate was more than 10%. Moreover, the freight volume increased over 20% to 92 million tons in 2013.

3.1.4.2 The statistic of amount of vessels which transferred dangerous cargo.

a. Annual vessels statistics

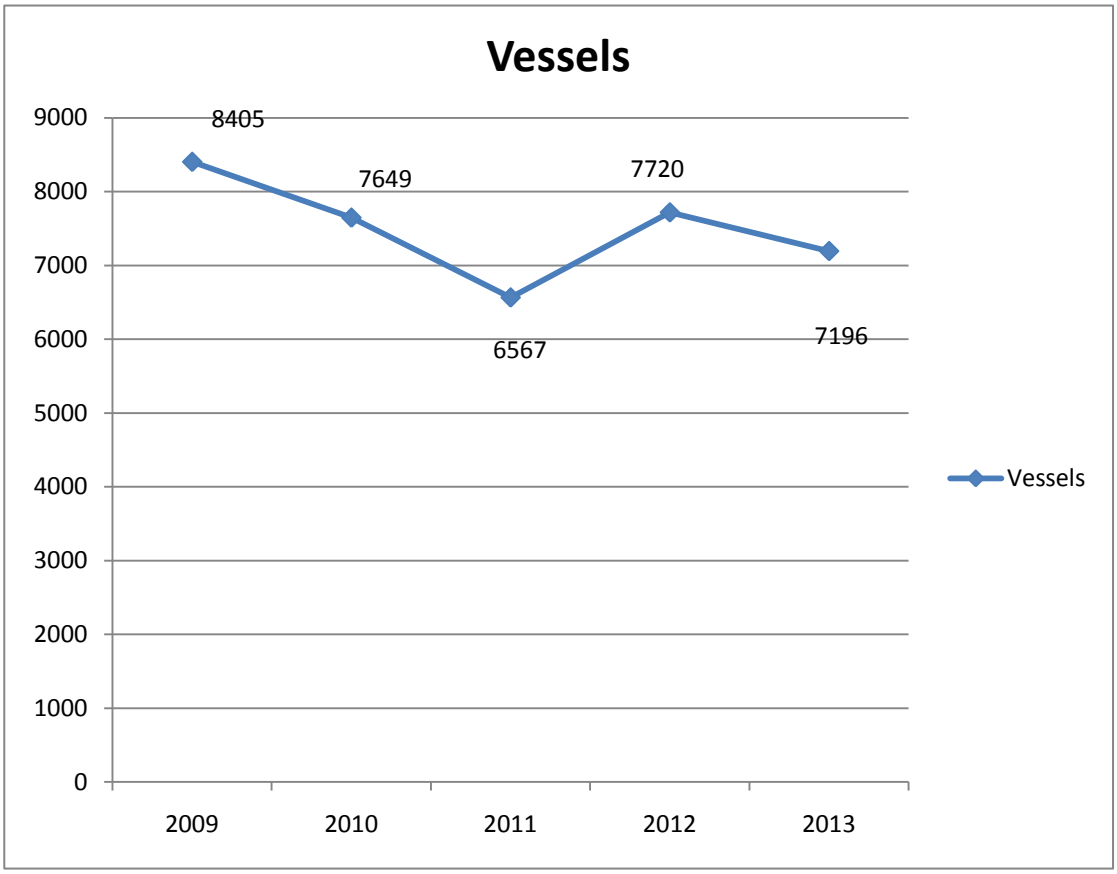

Figure 3.8 - Annual vessels statistics.

Source: Compiled by the author based on basic data.

A glance at the above chart clearly shows that the number of vessels that transferred dangerous cargo in Zhenjiang section of Yangtze River decreased slowly from 8405 to 7196 in the period of 2009-2011, and it reached the bottom 6567 vessels in 2011, and then rose up again to 7720 in 2012, with the growth rate of about 15%.

b. The vessels statistics in categories of dangerous cargo

category	Dangerous cargo in packed	Bulk solid	Liquefied gas	Bulk chemicals	Oils

	form				
Vessels	1670	219	21	2415	2871
Proportion	23%	3%	0.29%	33.56%	40%

Table 3.3 - Vessels statistics in categories of dangerous cargo.

Source: Data provided by the Department of Dangerous Cargo Management and Pollution Prevention of Zhenjiang MSA.

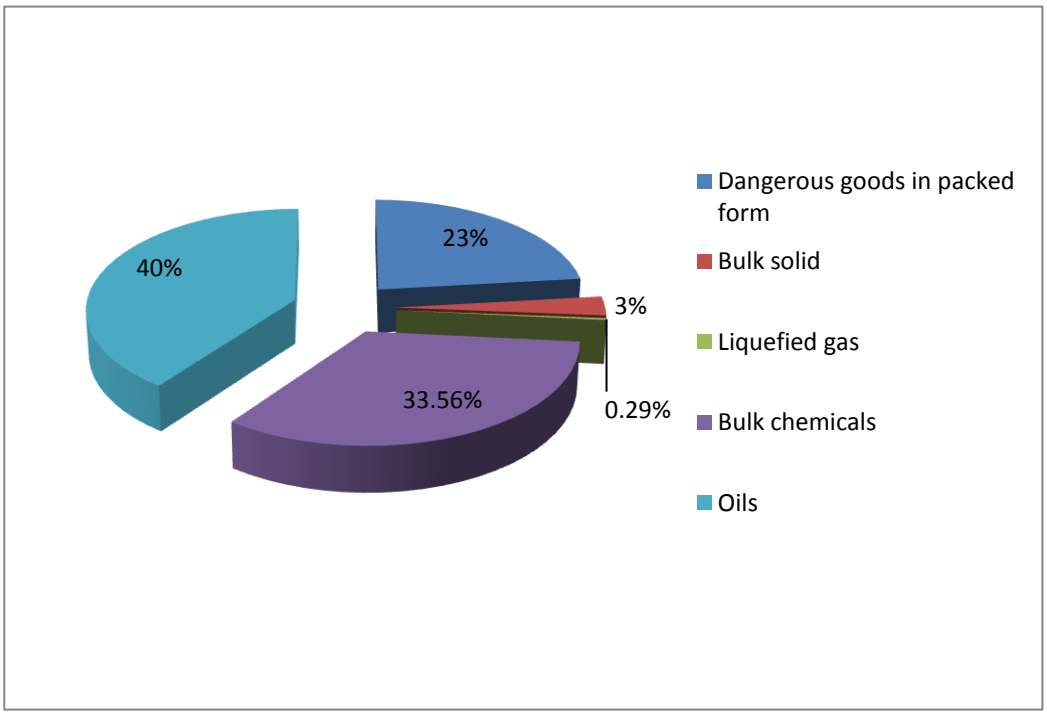

Figure 3.9 - Vessels statistics in categories of dangerous cargo.

Source: Compiled by the author based on basic data.

It can be seen from the pie chart above that, the oils, bulk chemicals and dangerous cargo in packed form still dominated dangerous cargo vessels. The number of bulk oil vessels was 2871, with the proportion of 40%, the number of container vessels that transferred dangerous cargo was 1760, with the proportion of 23% and the

number of bulk chemicals vessels was 2415, with the proportion of 33.7%

c. The vessels statistics according to the DWT.

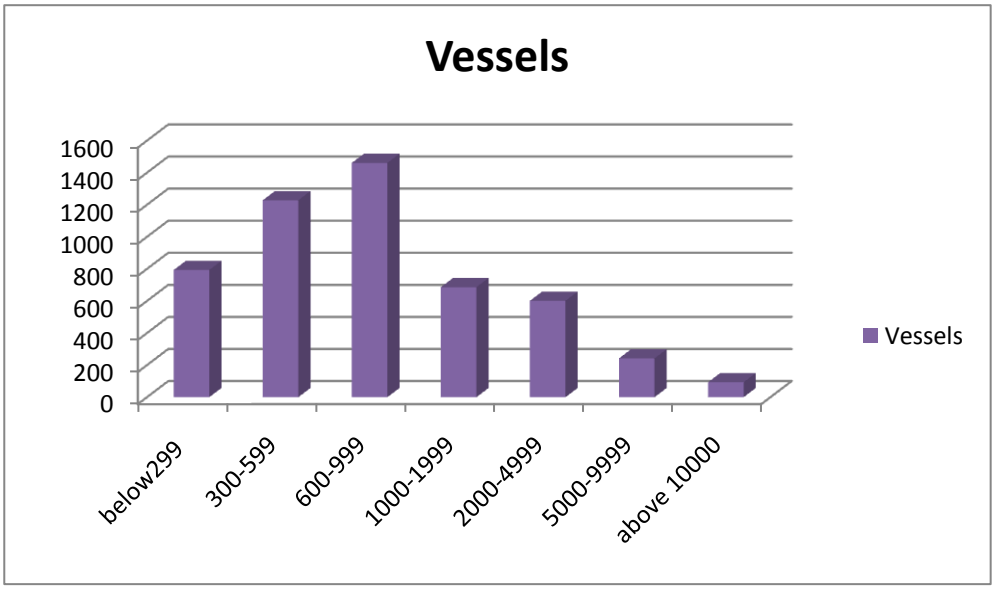

Figure 3.10 - Vessels statistics according to the DWT.

Source: Compiled by the author based on basic data

As can be seen from the bars graph above, the tanks below 999 DTW dominated the field. So the Small and medium-sized tankers are still the focus of supervision.

3.1.4.3 Freight volume statistics of different docks

	Vessels	Freight volume （ton）	Average Freight Volume per vessel	Proportion	Main types of cargo
DDR- sulfuric acid dock	151	46000	305	2.9％	Sulfuric acid
LCR-	154	229000	1487	3.0％	Methanol, methylal,

chemical engineering					acetone
JHHY Dock	447	1243000	2781	8.6%	Asphalt, Fuel oil
SOPO-Group	805	865000	1075	15.6%	Carbon dioxide, heavy oil, methanol, acetic acid, ethyl acetate, ethanol
CGRC	1112	1090000	980	21.5%	edible oil
JB oil depot dock	187	232000	1241	3.6%	Diesel, gasoline, methanol, ethanol, benzene, xylene, lubricating oil, fuel oil
GL-petrochemical engineering	1551	1545000	996	30.0%	Gasoline, diesel, methanol, alcohol, octanol, isononanol, o-xylene, butadiene, fuel oil, liquid sodium hydroxide
JS storage and transportation company	237	595000	2511	4.6%	Asphalt, LPG, base oil
Chimei-chemical engineering	523	938000	1793	10.1%	Styrene, methyl methacrylate, white oil, fuel oil

Total	5167	6783000	1310	100％	-

Table 3.4 - Freight volume statistics of different docks.

Source: Data provided by the Department of Dangerous Cargo Management and Pollution Prevention of Zhenjiang MSA.

The above table illustrates the statistics about the amount of vessels and the amount of freight volume within 9 dangerous cargo docks in Zhenjiang section of Yangtze River, the average annual freight volume of some docks is even more than 1 million tons.

3.1.5 Analysis of the dangerous cargo statistics

The freight volume of dangers cargo in Zhenjiang section of Yangtze River has developed steadily in recent years.

A total of 7196 vessels transferred dangerous cargo in Zhenjiang section of Yangtze River in 2013, and the freight volume was 14.5 million tons.

3.1.6 Risk of dangerous cargo docks

3.1.6.1 Problems of the management and operation of dangerous cargo docks

a. The employees' quality of the dangerous cargo docks is irregularity, and as a result, operations against rules happen occasionally. Some owners of the small-scale dangerous cargo docks which are the Historical legacies do not pay enough attention to the security. Meanwhile, as some operators have never been trained and are lack of knowledge about dangerous chemical, the dock operations are out of order and the potential safety hazard is very serious.

b. The dangerous cargo operators are quite mobile. Some of the operators who have been trained quit the job due to the bad performance of enterprises and the low salary.

c. The managers are lack of the cognition, awareness and measures to keep safety and do not pay enough attention to the importance of safety. They are always focusing too much on production and benefit but despising management and safety.

d. The safety facilities and equipments are lack of maintaining. Quite a part of the operating conditions of dangerous cargo docks is very simple and crude, with the damaged pipeline, lack of the fire fighting apparatus pollution prevention devices and antistatic aids. In addition, some of the video monitoring devices are short of maintaining. Monitoring images are blurred, the direction and position of cameras is inaccurate and the definition is low. Moreover, some of the monitors' operation is quite unskilled.

3.1.7 Dangerous cargo docks pollution prevention supervision institutions of Zhenjiang section of Yangtze River

Zhenjiang MSA is the pollution prevention supervision institutions of dangerous cargo docks within Zhenjiang Section of Yangtze River.

The Dangerous cargo management and pollution prevention office of Zhenjiang MSA performs duties according to the following domestic laws and international conventions:

"MARPOL73/78", IMO;

"OPRC 90", IMO;

“International convention on civil liability for oil pollution damage 1992”

“The regulation of safety supervision of transport of dangerous cargo by sea of People’s Republic of China”

“The regulation of pollution prevention of inland rivers of People’s Republic of China”

Meanwhile, Zhenjiang VTS provides the service to keep the navigation safety.
Zhenjiang VTS was built in 1997, and imported ATLAS 9760 System which owns a significant meaning to the vessels traffic management of Zhenjiang section of Yangtze River in 2009.

This system includes the radar system, VHF system, and Information processing and display system. In addition the system also contains the Information transmission, recording / playback system and Weather sensor system.

The functions that can be realized include: Data collection, assessment and treatment, traffic organization, navigation-aid service and so on.

At present, four radar stations, one microwave relay station, one VTS center have been built up to realize the monitoring of 125 kilometers of Yangtze River.

Although due to the good performance of the Zhenjiang MSA in the supervision, there are few pollution incidents in recent years, but the pollution prevention force of the Zhenjiang section of Yangtze River is still unsubstantial, which is reflected in

following three aspects:

a. Lack specialized personnel.

Pollution from vessels prevention is a comprehensive work which is: professional and highly technological.

So it needs a professional team with professional knowledge and skills. Although a social cleaning team exists in Zhenjiang section of Yangtze River, the members scatter in various industries. Thus they will be difficult to organiz if the pollution incident happens. In addition as, the team is lack of the professional knowledge and training, the cleaning efficiency and the effectiveness are poor. So it is difficult to complete the mission of the large area water pollution prevention and cleaning mission.

b. Lack of facilities.

Quite limited cleaning facilities can be used in Zhenjiang section. Meanwhile, this part of facilities cannot be used effectively due to the lack of cleaning facilities such as cleaning ships. So it is far from the requirements of dealing with the pollution incidents within the Zhenjiang section of Yangtze River.

c. Lack of working funds.

The source of funds for training workers, maintaining facilities and replenishing cargo and materials is quite limited. The pollution prevention special fund has not been subordinated to the government financial budget. The pollution prevention is restricted by the lack of funds.

Chapter 4 Source analysis

4.1 The development process of risk management in foreign countries

The theories of risk management were introduced until the Industrial Revolution in 18th century. The French managerialist Henri Fayol brought the theory into the Business field in the book “General Management and Industrial Management”. However, for a long time, the theory did not have a complete system. In the 1950s, the American developed it into a whole discipline, so the US is the acknowledged headstream of risk management.

The following table shows the development process of the risk management theory in the US:

1931	America Operators Association was set up to research and consult the problems concerning the risk management.
1950	The concept of risk management was exposited in detail in the book “Insurance” written by Mowbray.
1960	New York branch of the American Society of Insurance Management established the risk management courses along with Upsala University.

1961	Professor J, Edward hedges of Indiana University set up a special committee about “the curriculum concept of risk and insurance”, and then published “curriculum concept of risk and insurance “to point the direction of the training and education of the risk management field.
1963	“Risk Management in Business Enterprise” was published by Mehr and Hedges. This book became the most influenced in to the field.
1975	American Society of Insurance Management was renamed Risk& Insurance Management Society. This marks the switch of the risk management from the traditional treat risk with insurance to the treat risk with risk management.
1983	In the annual meeting of the RIMS, the experts and scholars discussed and passed the “The 101 risk management standards” as the general guideline of risk management in various countries.

Table 4.1 - Development process of the risk management theory in the US.

Source: Xu J,(2007). *Research on Risk Analysis and Management of Engineering Projects*. Unpublished master’s thesis, Xi'an University of Architecture and Technology, Xi'an, China.

It is worth mentioning that the US is outstanding in vocational education and training of risk management. In the middle of the 1970s, most of colleges with business administration and insurance majors set up the risk management courses, and brought in large numbers of professional personnel. In addition, the University of Pennsylvania held the qualification exam of risk management. If you pass the exam you will get an ARM diploma. This diploma is quite authoritative to indicate the qualification of risk management, and the diploma is also the qualification gist accepted by the US and western countries.

In 1984, PMBOK constituted by PMI considered the risk management as an

important part of its own, and amended this part in 2000. It shows the PMI emphasis on risk management.

The characteristic of the risk management of UK is different from that of the US. The professor C.B. Chapman from University of Southampton provided the concept of risk project in the book “Risk Analysis for Large Projects: Models. “Methods and Cases”. He thought that risk project is the integration of various kinds of analysis techniques and management methods to manage the risk more effectively with wider range and more flexible methods. This framework remedied the defects made by single process risk analysis and made the utilization of risk analysis research achievements possible.

Both the US and the UK which are the two mainstream countries in the risk management field have their own advantages in risk management field, and they are complementary.

4.2 The development status of risk management in China

China did not start to research the risk management until the 1980s. Professor GUO.Z.W from Tsinghai University started the research by publishing the book *“The partial derivative method function of the risk analyze of the Economic effects”* in 1987. And then the risk management and analysis system started to conform to international standard along with the deepening of reform and opening-up and then change of investment system. The China Ministry of Science and Technology started to do the fundamental research for the risk management in the form of project approval. It created the conditions of the domestic theory research and application research of risk management and then achieved a series of results. For instance

Tongji University finished the research about the risk analysis and risk management during the project implementation phase of a large-scale project.

And since the late 1990s, many other universities and research institutions have researched risk analysis theory at different levels, and published a large number of papers.

It can be seen from the domestic and foreign research review above that there is a wide gulf between China and western developed countries. To narrow the gap between home and abroad and to achieve breakthrough and innovation, not only are the managers are required to provide countermeasure that aim at real risk management problems, but the scientific workers who work on risk management also are to offer a whole set of risk management theories which can help understand and solve the problems in China. Meanwhile, the scientificity and effectiveness of the theories needs to be inspected to widen the application range of the theories.

4.3 Risk identification

4.3.1 Sensitive source analysis:

Yangtze River is the third longest river in the world and Asia's greatest river. The resources along the bank and under the water are quite abundant. In addition, The Yangtze River is the source of drinking water of most cities along the bank, especially in the middle and lower reaches of Yangtze River. So the number and variety of sensitive resources of Zhenjiang section of Yangtze River is considerable.

The following table is the analysis:

Area type	Number	The environmental protection target	Acreage （hectare）	Location	Level
The water intake area	1	Jiepai water intake	/	Right bank of Taipingzhou waterway	A
	2	Houxiang water intake	/	Right bank of Taipingzhou waterway	A
	3	Danyang water intake	/	Left bank of Hechangzhou	A
	4	Jinshan Waterworks water intake	/	1500m downstream of Zhenjiang-Yangzhou ferry	A
Aquaculture area	5	Shiye aquaculture area	15	Nearby Shiyezhou	B
	6	Jiaoshan waterway aquaculture area	17.5	Jiaoshan waterway	B
	7	Yangzhong puffer aquaculture	15.3	Yangzhong water area	B

Area type	Number	The environmental protection target	Acreage （hectare）	Location	Level
		area			
Ecological preservation area	8	Dolphin nature reserve of Jiangsu Province	5730	North branch of Hechangzhou	B
Tourism and entertainment area	9	Zhenjiang three-mountains tourism scenic area	4 476	South of Jiaoshan waterway	B

Table 4.2 - Sensitive resources of Zhenjiang section of Yangtze River.

Source: Compiled by the author using the data collected by the author

Figure 4.1 - Locations of sensitive resources of Zhenjiang section of Yangtze River.

Source: Compiled by the author using the data collected by the author

Risk identification is the base of sources analysis and risk evaluation, it will research the statistic analysis of the historical accidents and the typical cases to identify the source of danger and accidents, types of dangerous and criticality, and then confirm the main dangerous source.

4.3.2 The risk identification of the shipping process

The pollution incidents can happen during the navigation, berthing and loading & unloading process. The accidents can be divided into maritime accidents and operational accidents, as shown in fig.4-2

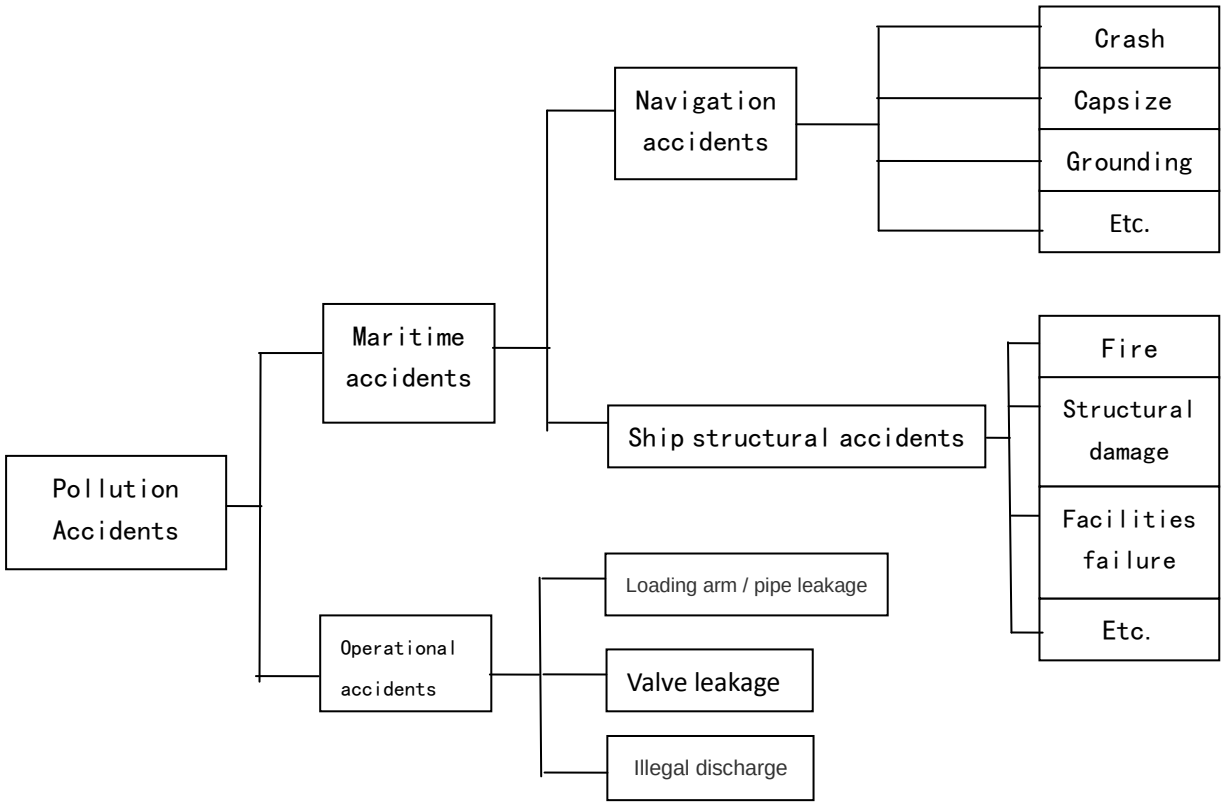

Figure 4.2 - Vessel pollution accident classification.

Source: Water transportation research institute of MOT of China. (2013). *The pollution risk analysis of the PetroChina Jingtang LNG port engineering. (p48)*. Beijing.

a. Maritime accidents

Direct or indirect causes of the vessel leakage include crash to each other, grounding, fire& exploding and capsizing or structure fracture

b. Operational accidents

The pollution incidents can also be caused by the pipe rupture, valve leakage and Illegal discharge.

4.3.3 Dangerous cargo transferred by vessels risk identification

The dangerous characteristic of the main dangerous cargo transferred in Zhenjiang section of Yangtze River will be listed in the appendix. The characteristics o the dangerous cargo are the main inner reasons of the fire explosion risk, leak spread hazard and environment pollution hazard. In addition, fire and explosion accidents can cause the larger-scale pollution accidents, and restrict antifouling emergency actions.

4.4 Risk factors analysis of ship pollution

4.4.1 Analysis of maritime accident factors

The reasons for the ship leak include the crash between the ships, grounding, capsizing and sinking in the wicked weather. The evaluation analyzes reasons for pollution accidents within the Zhenjiang section of Yangtze River in the view of the technology/engineering factors, management factors and environment factors.

4.4.1.1The technology/engineering factors

a. The channel and anchorage ground

As is mentioned above the length of the Zhenjiang section of Yangtze River channel is 108 kilometers, and the depth is 10.5 meters, which can meet the navigation requirements of up to 50,000-ton vessel. However, 9 anchorage grounds and some dangerous navigation zones exist in the channel. In addition, the dangerous anchorage grounds supporting the dangerous cargo docks have not been fixed. What' more, various docks are distributed along the bank and the number of the vessels is huge. So the accidents and the dangerous cases happen occasionally.

b. Docks arrangement and the design

All of the dangerous docks within the Zhenjiang section of Yangtze River conform to "Harbor total plane design specification (JTJ211-99)"," Code for fire protection design of oil docks (JTJ237-99)"," Basic safety technical requirements for oil dock (GB16994-1997)".

Loading and unloading process design is reasonable, safe, reliable; the potential safety hazard is eliminated to some extent. As a result, the designs reduce the risk of leakage, and pollution accidents.

c. Safety status of the vessels

As is mentioned above, more than 50% of the vessels which transferred dangerous in the Zhenjiang section of Yangtze River are below 999 deadweight tons. The conditions of the vessels are generally poor, and the work level of the operators on aboard is low, so the huge potential safety hazard exists here.

d. Navigation aids or navigational facilities.

The docks especially the dangerous docks and the channels within the Zhenjiang section of Yangtze River are fairly complete. And it is the same as the Navigation aids or navigational facilities. A total of more than 300 light buoys and more than 50 depthometers are set in the channel. In addition, the channel administration of Yangtze River has developed the Yangtze River Electronic Channel Chart edition 3.0 to improve the navigation condition gradually.

e. VTS center

Zhenjiang VTS was built in 1997.At present, four radar stations, one microwave relay station, one VTS center have been built up to realize the monitoring of 125 kilometers of Yangtze River. Zhenjiang VTS center has strengthened and normalized the traffic order to ensure the safety of vessels traffic and improve the transportation efficiency.

4.4.1.2Enterprise management factors

Enterprise management factors include the management system and emergency capacity mainly.

a. The systems of safe operation and the pollution accidents prevention and remedy are imperfect.

If the management systems, operating instruction and the contingency plans of dock enterprise are imperfect, or the wholesome and pointed systems of safe operation and the pollution accidents prevention and remedy have not been established, the vessel pollution accidents may occur. There are other reasons for vessel pollution accidents includes that the person in charge of enterprise or the managers and the operators

have not been trained, or the operators violate operational rules and the lack of response.

b. Emergency response capacity

Most of the dangerous docks within Zhenjiang section of Yangtze River are complete, and the emergency equipment and emergency facilities meet the requirements of the administration. Moreover, the Zhenjiang MSA also incepts the docks' regular aim at the emergency equipment and emergency facilities. It especially aims at whether the completeness and the amount of the oil booms, suction linoleums and oil dispersants conform to the emergency requirements.

In addition, the Jiangsu MSA Zhenjiang Pollution emergency equipments library built by Zhenjiang MSA will store a large number of the most advanced emergency equipment and emergency facilities in the future that the oil collecting machine and the UAV (unmanned aerial vehicle) etc.

Pollution emergency equipments library will be the core of pollution emergency response within Jiangsu section of Yangtze River when it is completed. The emergency response speed and quality will also get an all-round improvement.

4.4.1.3 Environmental factors

a. Impacts of wind

The impacts of wind on the vessels are obvious. The wind can stall the vessel or speed up the vessel. The degree or the characteristic of the impacts of the wind are connected with a number of factors, such as the windage area of the vessel, the position of wind power center, the ratio of freeboard height and the draught, wind

scale, wind angle, navigation course and navigation speed. The stronger wind will cause the more obvious incline, drifting and deflection.

①Deflection caused by wind

When the vessel stops, whether the wind comes forward of the beam or abaft the beam, the windward side will deflect to the angle of the wind abeam. At the same time, the vessel drifts leeward and finally stops to keep the wind angle of around 80 °.

If the wind comes forward of the beam when the vessel is navigating, the deflection caused by wind is codetermined by the wind speed, wind direction, vessel speed and load status. If the wind comes abaft the beam when the empty or ballast vessel is navigating, the bow of the vessel demonstrates a fortissimo windward deflection characteristic. Windward deflection is the result of the deflection caused by the wind, so, it is on the basis of a certain wind speed and a certain navigation speed.

②Drifting caused by wind

The develop trend of the deflection of the vessel which stops is the drifting to the leeward of the wind abeam. If the wind force Fa equals the water force Rw, the vessel will drift with constant speed. However, the vessel will drift to the lateral leeward if the vessel is navigating. If precondition is to keep the course, the track of the ship will not fit with the course. The drift angle which is the leeway depends on the drift speed and the navigation speed of the vessel.

Therefore, if the empty vessel is navigating in the channel in strong wind, it will drift a lot. So the constant-bearing navigation should not last a long time. And the impacts of the wind should be considered in the berthing and unberthing process.

b. The impacts of the flow

The flow within the channel of the Zhenjiang section of Yangtze River is fast, and there are many turnings. So the vessels are quite possible to meet the emergency situation such as loss of control when they are changing the course, especially in the summer flood period.

Therefore, the drift caused by the flow should be paid enough attention to.

c.The impact of the wave

The impact of the wave means the influence of the ship handling. The impact of the wave on the vessel can be divided into two parts. One part is the drifting force to the vessels and the other part is the moment of swing force. The vessels often deviate from voyage route or the channel in the former effect and the vessels swing consumingly in the latter effect. Both of them will cause the difficulties about the course control, speed control and position control.

4.4.2 Operational accidents risk factors analysis

The pipelines, loading arms and valves of the dangerous cargo dock may cause the cargo or fuel oil leak accidents. The leak accidents may have closely connection with the toxic gas diffusion, fire explosion and toxicosis accidents.

The Operational accidents can be divided into cargo unloading accidents, other operation accidents and illegal discharge.

4.4.2.1 Unloading accidents and other operation accidents

a. Due to the lack of responsibility, the operators on duty operate against the regulations or they do not incept or monitor the unloading operation enough cause the leak accidents.

b. The failure of the loading arms, loading arms damaged during the cargo unloading cause the leak accidents.

c. The equipments have not been maintained and changed in time; the piercing and the fracture of the equipments cause the leak accidents.

d. The pressure piping crevices of the dock and approach bridge cause the leak accidents.

e. The flange joints of the pipes are insecure, the break and the falling off of the valves cause the leak accidents.

f. The wrong valves are opened by the crew members.

g. The collision and grounding caused by human factors of the vessels drivers.

h. Strong wind breaks the mooring rope and causes the collision between the docks and the vessels.

i. The crew members and the operators cannot use the equipments expertly

4.4.2.2 Illegal discharge

Due to the technical conditions and the maintenance of equipment problems, the

crew member discharge oily sewage such as the engine room sewage and the tank washings illegally.

4.5 The results of the risk identification

4.5.1 Risk accidents types

The risk types of the vessel pollution accidents include the operational vessel pollution accidents and maritime pollution accidents.

The operational vessel pollution accidents can be divided into cargo unloading accidents, other operation accidents and illegal discharge. The maritime pollution accidents happen along with the traffic accidents, and the causes are almost the same.

4.5.2 Main risk factors

Based on the above analysis, the technology/engineering factors, enterprise management factors and the environmental factors are the causes of the pollution accidents within the Zhenjiang section of Yangtze River. In addition, the navigation conditions such as the channel conditions and the flow of vessels are the main factors of the traffic accidents and the pollution accidents.

4.5.3 The locations and causes of the accidents

The operational accidents mainly occur in the dock, the maritime accidents mostly happen in the channel and the anchorages, while the fire explosion accidents may happen in all of the locations.

The model locations and causes of the accidents are shown in the following table:

Location	Source	Representative reason
Channel; Anchorage	Vessel	Grounding、Collision、Adverse sea condition（Fog、Typhoon）、Fire explosion、Illegal discharge
Quayside water area	Vessel	Collision、Cargo unloading、Valve leak、Misoperation、Fuel oil leak

Table 4.3 - Model locations and causes of the accidents.

Source: Data provided by the maritime accidents investigation team.

Chapter 5 Accidents analysis

5.1Vessels accidents statistics and analysis

5.1.1Vessels traffic accidents statistics and analysis

According to the statistical material of the Zhenjiang MSA, 548 traffic accidents happened in Zhenjiang section of Yangtze River between 2007 and 2011. The number of accidents in each year is shown in table 5-1, and the type of traffic accidents is shown in table 5-2:

Year	2009	2010	2011	2012	2013
Amount	160	159	64	72	93

Table 5.1 -Traffic accidents amount statistics from 2009-2013 in Zhenjiang section of Yangtze River.

Source: Data provided by the maritime accidents investigation team.

Type	Amount	Proportion	Annual Average
Collision	434	79.20%	86.8
Grounding	66	12.04%	13.2
Contact loss	20	3.65%	4
Swell damage	4	0.73%	0.8
Wind damage	13	2.37%	2.6
Sink	12	2.19%	2.4

Total	548	100.00%	109.6

Table 5.2 - Traffic accidents type statistics from 2009-2013 in Zhenjiang section of Yangtze River.

Source: Data provided by the maritime accidents investigation team.

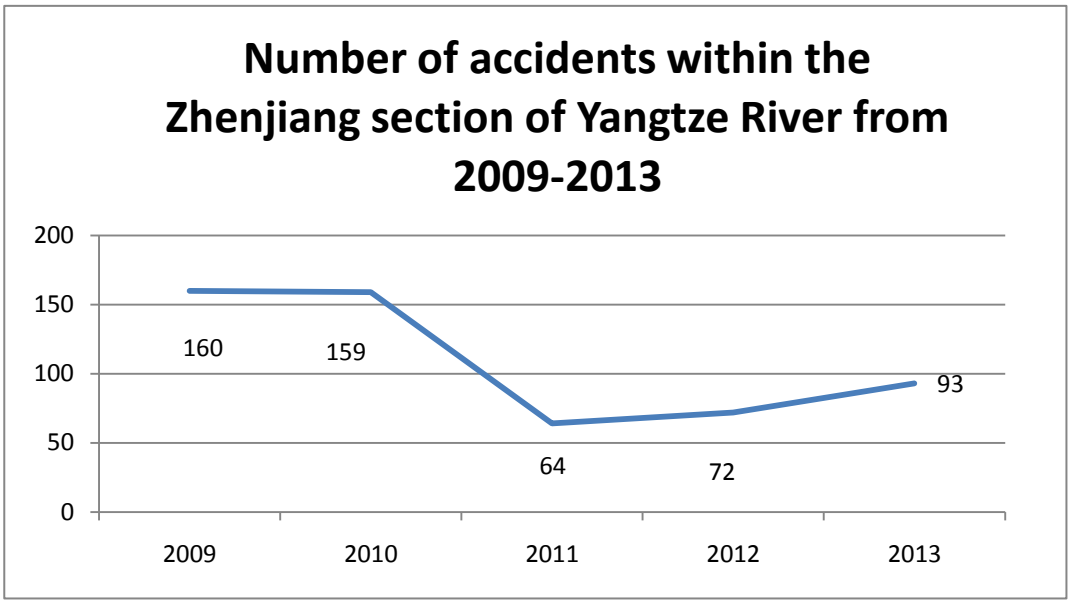

Figure 5.1 - Number of accidents within the Zhenjiang section of Yangtze River.

Source: Compiled by the author based on basic data.

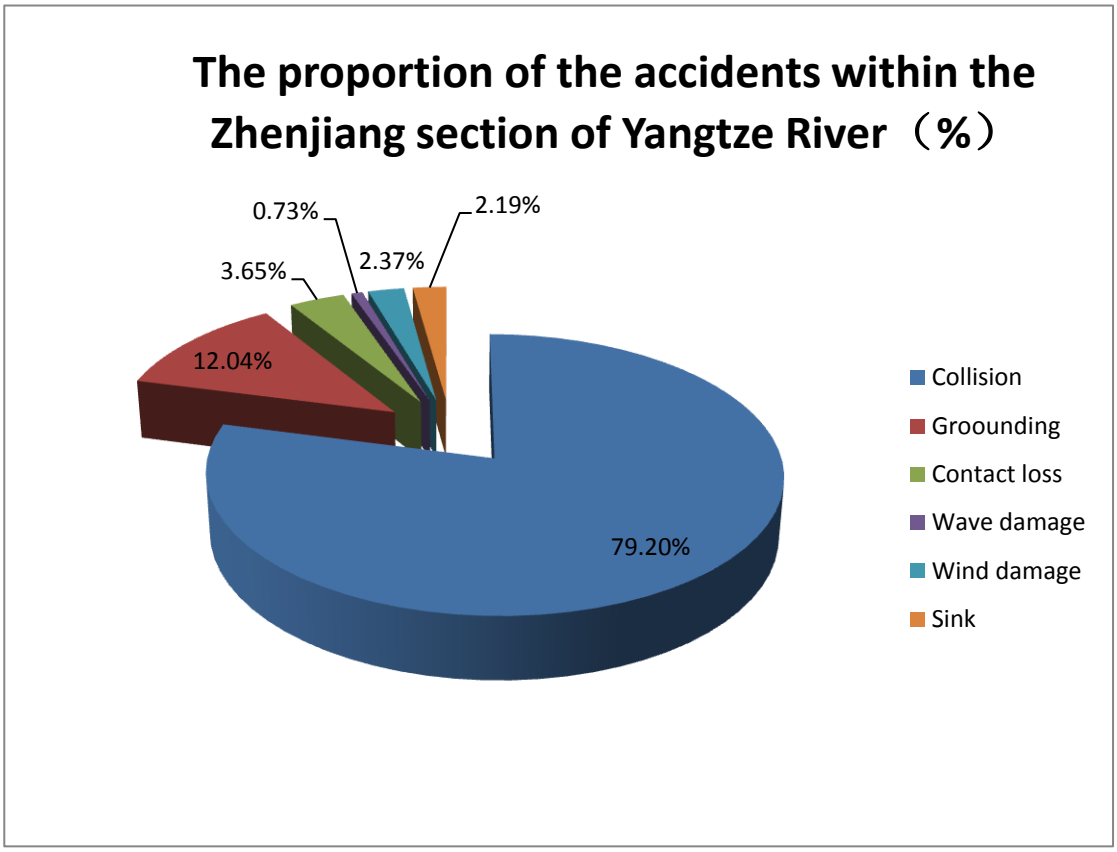

Figure 5.2 - Proportion of the accidents within the Zhenjiang section of Yangtze River.

Source: Compiled by the author based on basic data.

As is shown in figure 5-2, the traffic accidents within Zhenjiang section of Yangtze River decreased steadily from 2009-2013. Collision accidents took 79.2% among them, and the proportion of grounding, contact loss and wind damage is 12.4%、3.65%、2.37% respectively.

5.1.2 Vessels pollution accidents and pollution load statistics and analysis

According to the statistics, a total of seven pollution accidents happened in the Zhenjiang section of Yangtze River. The specific data are shown in table 5-3

NO.	Time	Location	Name	Type	Pollutant Type	Amount
1	January 12, 2009	Yizheng waterway of the Yangtze River	“M/V JIN HAI TENG”pollution accident	operational	Oily water	0.1ton
2	June 3, 2009	Zhenjiang Dagang No. 2 berth	"M/V Sheng Tai marine" pollution accident	operational	Oily water	0.05ton
3	August 31, 2009	Zhenjiang Dagang No. 9 berth	“M/V Rongfeng” pollution accident	operational	Oily water	0.18ton
4	December 6, 2009	JHHY NO.3 berth	“M/V Jiangyanyou 9999” pollution accident	operational	Fuel oil	0.003ton
5	May 12, 2010	Longmen port	“M/V TRANSOCEAN” pollution accident	operational	Fuel oil	0.001ton
6	February 3, 2012	Li Chang Rong integrated petrochemical	“FC GLORIA” pollution accident	operational	Toxic hazards	44ton

		PORT				
7	January 21, 2013	JHHY NO.3 berth	“M/V Yu RUN 1” pollution accident	operational	Fuel oil	0.02ton

Table 5.3 - Vessels pollution accidents in Zhenjiang section of Yangtze River from 2009-2013.

Source: Data provided by the Department of Dangerous Cargo Management and Pollution Prevention of Zhenjiang MSA.

5.2 The frequency of vessels accidents

5.2.1 The frequency of vessels traffic accidents

According to the vessels traffic accidents statistics of Zhenjiang section of Yangtze River, a total of 548 vessels traffic accidents happened from 2009-2013. 109.6 accidents happened annually on average.

According to the vessels traffic accidents analysis, the highest probability of accidents types are collision, grounding and sink, the probability of occurrence is 86.8, 13.2 and 2.6 accidents probability of occurrence per year .

A total of 499,611 vessels had been to Zhenjiang port in the period of 2009-2013, so the accident probability is1.09×10-3/portcalls.

5.2.2 Vessel pollution accident frequency

According to the statistical material, a total of 7 pollution accidents happened in Zhenjiang Section of Yangtze River from 2009-2013, 1.4 accidents happened annually on average.

A total of 499611 vessels had been to Zhenjiang port in the period of 2009-2013, so the accident probability is1.40 ×10-5/portcalls.

5.3 The statistics and analysis of pollution load

A total of 7 pollution accidents happened in Zhenjiang section of Yangtze River from 2009-2013. Although the pollution load was quite limited, it would also cause a serious result due to the sensitive targets such as the water intake area, aquaculture area, ecological preservation area and tourism and entertainment area.

5.4 Accident black spots

According to the above accidents' statistics and analysis, we can confirm the risk region of the Zhenjiang section of Yangtze River:

5.4.1 The quayside and the channel

The vessels may strike, extrude and rub the dock during the berthing and unberthing procedure. The dock may get damaged by the overlarge impact force if the vessel is too fast.

Moreover, the Dantu waterway and the Jiaoshan straight waterway are the regions where the accidents happen very frequently.

5.4.2 Anchorage area

9 anchorage areas are set in the Zhenjiang section of Yangtze River without exclusive

anchorage area for the dangerous cargo vessels. The anchorage areas are also open to the bulk carriers and container vessels which are quite concentrated. The berthing and unbertheing will influence other vessels which are entering the anchorage area and cause the collision risk hazard.

The accident black spots are shown in the following figure:

Figure 5.3 - Accident black spots.

Source: Compiled by the author based on basic data

5.5 Risk impacts prediction:

a. There are some drinking water intakes within the Zhenjiang section of Yangtze River such as Jiepai water intake, Houxiang water intake, Danyang water intake and Jinshan Waterworks water intake. The emergency pollution accidents will influence the water quality. In recent years, the emergency pollution accidents have made the waterworks stop to supply the water several times.

In addition, the Zhenjiang section of Yangtze River is tidal reach, the pollution accidents will not only influence the downstream cities such as Changzhou, Taizhou and Nantong, but also the upstream cities like Nanjing, Wuhu and Mananshan.

b. A mass of places of interests are located along the Yangtze River bank, therefore, the pollution accidents will damage them.

c. Many aquaculture bases such as globefish aquiculture areas and crab aquiculture areas are set in the Zhenjiang section of Yangtze River; the pollution accidents will cause large economical losses. In addition, the north branch of Hechangzhou water area is also the provincial level dolphin nature protection area; it is the habitat of the white-flag dolphin which is referred to as "live fossil" and a large number of the finless porpoise. So the loss caused by pollution accidents is immeasurable.

d. Zhenjiang is located at the river network region; the urban rivers connect with the Yangtze River through the ancient canal, inner Yangtze River and Yunliang River. Once the pollution accident happens, the pollutant will enter into the urban area and cause heavy losses.

Chapter 6 Risk evaluation

6.1 Prediction of high risk areas

This part will predict the high risk areas of the Zhenjiang section of Yangtze River on the basis of risk identification and risk impact prediction.

6.1.1 The quayside

The upstream and downstream of the dangerous dock in Zhenjiang section of Yangtze River are other docks. For example, the upstream of the LCR chemicals dock is the power generating company dock and the downstream of the SOPO Group dock is JB power plant dock. This case is much more serious in Dagang area, for the distances among the Ganglong petroleum and chemical industry dock, JB oil depot dock and the CHIMEI dock are all short. Therefore, the collision happens sometimes.

6.1.2 The channel and anchorage area

The navigation condition of the Zhenjiang section of Yangtze River is quite complicated, the dangerous case happens frequently, especially in the Dantu waterway and the Jiaoshan straight waterway; in addition, there is no dangerous cargo vessels' exclusive anchorage, so all the anchorages near the dangerous cargo dock are high risk areas.

6.2 Acceptable level of risk

The evaluation part of this essay will use the risk matrix method of the "The vessels pollution of the marine environment risk assessment technical specification". The risk matrix is made up of two parts, the accident probability and the hazard results. In the risk matrix, the risk level can be divided into acceptable area, unacceptable area and medium risk area.

a. Acceptable area: it is located at the bottom of the matrix, the probability is extremely low, and the consequences are not obvious, so the risk can be ignored or not any solutions are needed to be taken.

b. Unacceptable area: it is located at the top of the matrix, the probability is extremely high, and the consequences are disastrous. It is necessary to take measures to reduce the risk level to the medium risk area.

c. Medium risk area is located at the middle of the matrix, both of the probability and the consequences are in the middle level. It is also necessary to take measures to control the risk.

The relevant emergency measures corresponding different pollution risk levels should be taken to reduce the risk level. The specific measures are shown in the following table.

Risk level	Measures and time scale of risk reduction

Low	The risk does not need to be controlled in most cases but it needs tracking monitoring .In addition, the feasible measures plan should be considered to prevent the risk level increase.
Medium	The measures which can reduce the risk should be taken.
High	Various comprehensive measures, manpower and material resources should be taken to reduce the risk below the medium level.

Table 6.1 - Risk level and the corresponding measures.

Source: The vessels pollution of the marine environment risk assessment technical specification, CHINA MSA. (2011)

6.2.1 Operational pollution accidents risk evaluation.

According to the operational vessels pollution incidents' classification standard of "The vessels pollution of the marine environment risk evaluation technical specification" and the "Operational vessels pollution incidents hazard consequences classification standard" which shown in table 6.2, the hazard consequences and probability classification results of vessels pollution are shown in table 6.3

Classification	Explain	Definition
P1	High	An event happens every year
P2	Medium	An event happens every 1-5 year
P3	Low	An event happens every 5-10 year

Table 6.2 - Classification of the operational vessels pollution risk probability.

Source: The vessels pollution of the marine environment risk assessment technical specification, CHINA MSA. (2011)

Classification	Explain	Definition
C1	Serious	Leakage is above 50tons, direct economic loss is above 5 million or cause serious impacts on environment
C2	General	Leakage is between 10 and 50tons, direct economic loss is below 5 million or cause general impacts on environment
C3	Slight	Leakage is below 10tons, direct economic loss is below 2.5 million or cause little impacts on environment

Table 6.3 - Classification of the operational vessels pollution risk hazard consequences

Source: The vessels pollution of the marine environment risk assessment technical specification, CHINA MSA. (2011)

Risk level / Hazard consequences / Risk probability	Slight	General	Serious
Low			High risk area
Medium		Medium risk area	
High	Low risk area		

Table 6.4 - Operational vessels pollution accident risk evaluation matrix.

Source: The vessels pollution of the marine environment risk assessment technical specification,

CHINA MSA. (2011)

Because of a large amount of leakage (The most possible leakage is 42t), and the high accident probability (about one event in 0.7 years), the operational pollution incidents risk is in the high risk area. So the tracking monitoring and the measures are needed to reduce the risk level.

6.2.2 Maritime pollution incidents risk evaluation

According to the operational vessels pollution incidents classification standard of "The vessels pollution of the marine environment risk assessment technical specification" and the maritime vessels pollution incidents hazard consequences classification standard which is shown in table 6.5, the hazard consequences and probability classification results of vessels pollution shown in table 6.6

Classification	Explain	Definition
P1	Extremely High	An event happens every year
P2	High	An event happens every 1-10 years
P3	Medium	An event happens every 10-50 years
P4	Low	An event happens every 50-100 years
P5	Extremely Low	An event happens every 100-1000 years
P6	Extremely Impossible	An event happens above 1000 years

Table 6.5 - Classification of the maritime pollution accidents risk probability.

Source: The vessels pollution of the marine environment risk assessment technical specification, CHINA MSA. (2011)

Classification	Explain	Definition
C1	Catastrophic	The incident level is extremely serious, leakage is above 1000 tons, and direct economic loss is above 1 billion or cause catastrophic impacts on environment.
C2	Extremely Serious	The incident level is extremely serious, leakage is above 1000 tons, and direct economic loss is above 0.2 billion or cause serious impacts on environment.
C3	Serious	The incident level is serious, leakage is between 500 tons and 1000 tons, and direct economic loss is between 0.1 billion and 0.2 billion or cause serious impacts on environment.
C4	Relatively Serious	The incident level is relatively serious, leakage is between 100 tons and 500 tons, and direct economic loss is between 50 million and 0.1 billion or cause relatively serious impacts on environment.
C5	General	The incident level is general, leakage is between 50 tons and 100 tons, and direct economic loss is between 10 million and 50 million or cause general serious impacts on environment.
C6	Slight	The incident level is Slight, leakage is below 50 tons, and direct economic loss is below 10 million or cause general little impacts on environment.

Table 6.6 - Classification of most possible accident consequences.

Source: The vessels pollution of the marine environment risk assessment technical specification, CHINA MSA. (2011)

Risk level / Hazard consequences / Risk probability	Slight	General	Relatively Serious	Serious	Extremely Serious	Catastrophic
Extremely High						High risk area
High						
Medium			Medium Risk area			
Low						
Extremely Low						
Extremely Impossible	Low risk area					

▲ Most possible pollution incidents

Table 6.7 - Maritime vessels pollution accident risk evaluation matrix.

Source: The vessels pollution of the marine environment risk assessment technical specification, CHINA MSA. (2011)

6.3 Summary

Based on the prediction of high-risk areas and the analysis of risk acceptable level above, we can get the summary as follows:

a. The high risk areas of the Zhenjiang section of Yangtze River are the quaysides, Dantu waterway and the Jiaoshan straight waterway and the anchorage areas.

b. According to the results of the risk matrix analysis, the risk level of maritime pollution incidents is low while the operational incidents risk level is high. So it is necessary to take measures to reduce the risk level.

Chapter 7 Measures of risk level reduction.

The meaning of risk level reduction is quite significant. The MSA is in the important position in the risk level reduction, so the measures should be comprehensive.

7.1 Strengthen supervision

To prevent of emergency vessels pollution accidents, the MSA, port administration and the government should strengthen the supervision with the following methods

7.1.1 Strengthen the supervision of the vessels and seafears

First of all, the MSA should strengthen the on-the-job training and integrated management of the seafears according to the STCW convention to improve the basic quality of the seafears, help them acquire the knowledge and abilities to reply the emergency vessels accidents. Secondly, the MSA should require the vessel to equip and update advanced monitoring methods and technologies, and install the necessary equipments, cargo and materials, for instance, the oil boom and oil absorbent felt to deal with the emergency pollution accidents. The supervision methods to the vessels will control the source of vessels' pollution accidents and prevent the pollution accidents actively.

7.1.2 Strengthen the supervision of the water transportation

The MSA should supervise the water transportation with the advanced information technology. And the large –scale dangerous cargo vessels should be supervised in the whole journey. The VTS should label and track the dangerous cargo vessels which enter the control water areas. If the vessels are navigating, berthing or operating illegally, the VTS center should warn them timely and take coercive measures to reduce the risk level.

What's more, the VTS center should also control and prevent the marine accidents such as collision and fire explosion. And the dangerous cargo leakage accidents should be prevented particularly.

7.1.3 Strengthen the supervision of port enterprises and port operation

The administrative department of the ports should strengthen the supervision of port enterprises through the management of enterprise qualification, inception of port operation conditions, supervision of the operators and the loading& unloading procedure which according to laws to prevent the leak pollution accident. Moreover, the administrative department of the ports should strengthen the exchange of supervision information with the MSA. The two departments should supervise the vessels which are berthing or stay in the control area synergistically

7.2 Strengthen scientific research

7.2.1 The research of the leakage diffusion law

The leakage is diverse, containing flotage and sediment in terms of density and it also can be divided into solid and liquid in terms of form.

If the leak accident happens, on one hand, these matters will diffuse, volatilize, precipitate and dissolve in the flow, and on the other hand these matters will react with water. So it is necessary to research the leakage diffusion law to predict the accident scale, range of influence and accident development and then provide the measures targeted.

In addition, due to the impacts of the tide, the flow condition of the Zhenjiang section of Yangtze River is quite complicated. The complexity is not only shown in the time domain which means the change of the flow is a random process, but also shown in the space that the change of flow depends on the spatial position which means the flow velocity and the flow direction are different even in different spatial positions of the same section.

Therefore, the flow field should be researched first by various experiments. And then the diffusion law can be researched by the relevant diffusion theory on the basis of research results of flow field.

7.2.2 The research of the modern information technology application

The modern information technology not only helps the administration to improve the supervision methods to supervise the safety of vessels traffic but also helps the administration provide more scientific approaches to deal with the leak accidents.

For example, utilization of the modern technologies such as GIS, GPS and 3G/4G in the real time supervision of the vessels in the Zhenjiang section of Yangtze River will prevent the pollution accidents effectively. In addition, even if the pollution accident

happens, the information such as location, vessel conditions and leakage amount will be sent to the MSA to take measures to prevent the expansion of the accident, and to reduce the loss to the minimum.

7.3 Build up emergency response plan

It is necessary to build up relevant emergency response plans, according to the specific conditions of the Zhenjiang section of Yangtze River. The Zhenjiang government and relevant administrations have issued a series of emergency response plans. For instance, Zhenjiang government issued “Emergency plans for the especially serious safety accidents”; the environmental protection agency issued “Emergency plans for environmental pollution accidents”; Zhenjiang MSA also issued the “Emergency plan” for the dangerous characters of Yingongzhou section of Yangtze River; the port authority of Zhenjiang city issued the “Emergency plan for the ports along the Yangtze River” and the Zhenjiang environmental monitoring station is preparing the “Emergency monitoring plan of sudden environmental pollution accidents”. All of the above plans provide the support to the emergency accidents processing. Therefore, Zhenjiang MSA should formulate an “Emergency plans for environmental pollution accidents of Zhenjiang section of Yangtze River” based on the other emergency plans.

On one hand, the “Emergency plans for environmental pollution accidents of Zhenjiang section of Yangtze River” should link the previous emergency plans, on the other hand the plan should make full use of emergency resources to make itself feasible.

Chapter 8 Conclusion

With the economic development, the amount of the dangerous cargo along with the growing transportation capacity is increasing year by year. The explosion, fire and leak accidents may easy to happen. The accidents will not only cause the economical loss but also influence the environment. Therefore, it is necessary to evaluate the risk to enlighten the administrations. The development status and management status are analyzed deeply; the problems and risks are pointed in this essay. Then the matrix method is adopted on the basis of the general situation of domestic and foreign risk evaluation research.

The risk level of the dangerous cargo docks within Zhenjiang section of Yangtze River is not very high, but due to the special location of the Zhenjiang section of Yangtze River, the terrible results may be caused by the potential risk.

Therefore, the relevant administrations should pay enough attention to the risk of Zhenjiang section of Yangtze River and should issue the risk management measures which aim at the influencing factors such as the cargo, ship conditions, operators, safety management and the dock facilities to ensure the safety of Zhenjiang section of Yangtze River

Due to the limit of the author’s ability, some further research has not been finished yet:

a. During the inquiry, for some certain reasons, the range is not wide enough and the valid data is also not enough. Moreover, the calculation results have the deviation because of the lack of samples.

b. During the evaluation process, the impacts of the leakage of atmosphere, water and natural environmental protection areas can be researched further to find out some more accurate and scientific methods.

c. We should evaluate the risk and impacts of the dangerous cargo dock of Zhenjiang section of Yangtze River through various suitable models to find out a most suitable method of risk research which can be used by other ports for reference.

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Appendix A

The dangerous characteristic of the main dangerous cargo transferred in Zhenjiang section of Yangtze River.

Category	Item	Methanol
Physical and chemical properties	Appearance and properties	Transparent、Colorless liquid
	Fusion point	-98℃
	Boiling point	-64.5-64.7℃
	Relative density	0.791 g/mL at 25 ℃
Combustion and explosion risk	Flashing point	11℃
	Self ignition point	385℃
	Explosion limit	5.5～44（V%）
	Stability	Stable
	Hazardous characteristics	Inflammable，the steam and air can be formed to explosive mixture. Combustion and explosion caused by the fire and high heat. Chemical reaction or combustion caused by the contact with oxidizing agent. The heated container may explode in the fireground

	Extinguishant	Dry powder、Carbon dioxide
The toxicological properties	Toxicity	LD505628mg/kg(Big rat form mouth)；15800mg/kg(Rabbit from skin)；LC5082776mg/kg，4hours(Big rat inhalation)
	Health Hazard	Methanol is toxic to the human body, because methanol in human will be oxidized into formaldehyde and formic acid which are much more toxic, so drinking methanol can cause blindness, liver disease, and even death. Drinking more than 4 milliliter will cause poisoning symptoms, drinking more than 10 milliliter can cause blindness due to permanent damage to the optic nerve, drinking more than 30 milliliter can lead to death.
	Emergency plan	Move the patient to the fresh air immediately, use artificial respiration if necessary
Protective measures	The operators are advised to wear the filtration mask (half mask), chemical safety goggles, antistatic clothing and Rubber gloves.	
Leakage treatment	Evacuate the person in the evacuated area to safe area immediately, and lock the leakage area. Cut off the fire source. The operators should wear the positive pressure self-contained breathing apparatus. Do not touch the leakage directly. Cut off the leakage source to prevent the leakage inflow into the sewer where the space limited. A small amount of leakage: absorb the leakage with soil or non-combustible material or dilute the leakage with water and then	

	treat it with waste water system. A big amount of leakage: cover the leakage with foam to reduce the steam disaster. Transfer the leakage to the exclusive container.
Store	Store it in the shady, cool and ventilated storeroom. Keep it far from the kindling and heat source. The storeroom should cooler than 30℃. The container should be kept sealed. It should separate from the oxidizing agent, acid and alkali metal. The storeroom should use explosion-proof lighting and ventilate facilities. The mechanical equipments and tools which may produce the spark should be forbidden. The store area should stock emergency leakage treatment equipments and suitable container.

Category	Item	Acetone
Physical and chemical properties	Appearance and properties	Colourless liquid
	Fusion point	-94.7℃
	Boiling point	56.05℃
	Relative density	0.7845 g/mL at 25 ℃
Combustion and explosion risk	Flashing point	-20℃
	Self ignition point	465℃
	Explosion limit	2.5～13（V%）
	Stability	Stable
	Hazardous characteristics	Inflammable，the steam and air can be formed to explosive mixture. The steam is heavier than air, is able to diffuse far away in the low area, and backdraft by the heat source. In case of high fever, increased pressure within the container, cracking and explosion may happen.
	Extinguishant	non-fusibility foam, carbon dioxide, dry powder, soil
The toxicological properties	Toxicity	LD50：5800 mg/kg(Big rat from mouth)；20000 mg/kg(Rabbit from skin)
	Health	Acute poisoning mainly manifests anesthetic effects

	Hazard	on the central nervous system, fatigue, nausea, headache, dizziness, irritability. Severe vomiting, shortness of breath, spasm, and even coma. The eyes, nose, and throat irritation. After oral, the mouth, throat burning sensation firstly, than the thirsty, vomiting, coma, acidosis and ketosis. Long term exposure will cause the burning sensation, dizziness, pharyngitis, bronchitis, fatigue, irritable etc... The long-term repeated exposure may cause skin dermatitis.
	Emergency plan	Skin contact: remove contaminated clothing; wash the skin thoroughly with soap and water. Eye contact: filed eyelid, rinse with water or saline. Medical treatment. Inhalation: remove to fresh air. To maintain airway patency. If breathing is difficult, give oxygen. If not breathing, give artificial respiration. Medical treatment. Ingestion: drink plenty of warm water, emetic. Medical treatment
Protective measures	The operators are advised to wear the filtration mask (half mask), chemical safety goggles, and antistatic clothing and Rubber gloves.	
Leakage treatment	Evacuate the person in the evacuated area to safe area immediately, and lock the leakage area. Cut off the fire source. The operators should wear the positive pressure self-contained breathing apparatus. Do not touch the leakage directly. Cut off the leakage	

	source to prevent the leakage inflow into the sewer where the space limited. A small amount of leakage: absorb the leakage with soil or non-combustible material or dilute the leakage with water and then treat it with waste water system. A big amount of leakage: cover the leakage with foam to reduce the steam disaster. Transfer the leakage to the exclusive container.
Store	Store it in the shady, cool and ventilated storeroom. Keep it far from the kindling and heat source. The storeroom should cooler than 26℃. The container should be kept sealed. It should separate from the oxidizing agent, acid and alkali metal. The storeroom should use explosion-proof lighting and ventilate facilities. The mechanical equipments and tools which may produce the spark should be forbidden. The store area should stock emergency leakage treatment equipments and suitable container.

Category	Item	Petrol
Physical and chemical properties	Appearance and properties	Colorless transparent liquid
	Fusion point	/
	Boiling point	/
	Relative density	0.72-0.737 g/mL
Combustion and explosion risk	Flashing point	≥55℃
	Self ignition point	415-530℃
	Explosion limit	1.4-7.6（V%）
	Stability	Stable
	Hazardous characteristics	Inflammable，the steam and air can be formed to explosive mixture. The steam is heavier than air, is able to diffuse far away in the low area, and backdraft by the heat source.
	Extinguishant	Foam, Dry powder, Carbon dioxide
The toxicological properties	Toxicity	Low toxicity
	Health Hazard	Acute poisoning: the anesthetic effect on the central nervous system. Symptoms of mild poisoning: dizziness, headache, nausea, vomiting, unsteady

		gait, ataxia. : Inhalation of high concentrations of toxic encephalopathy. High concentration of inhalation caused by sudden loss of consciousness, reflecting respiratory arrest. May be associated with neuropathy and chemical pneumonia. Some patients with psychosis. Liquid is sucked into the respiratory tract can cause aspiration pneumonia. Splashed into eyes can cause corneal ulcer, perforation, and even blindness. Skin contact induced acute contact dermatitis, even burn. Swallowing cause acute gastroenteritis, or similar acute inhalation poisoning symptoms, and can cause liver, kidney damage. Chronic poisoning: neurasthenic syndrome, symptoms of autonomic function similar to schizophrenia. Skin damage.
	Emergency plan	Skin contact: immediately remove contaminated clothing; wash the skin thoroughly with soap and water. Medical treatment. Eye contact: immediately filed eyelid, with large flows of water or saline rinse thoroughly at least 15 minutes. Medical treatment. Inhalation: remove to fresh air. To maintain airway patency. If breathing is difficult, give oxygen. If not breathing, give artificial respiration. Medical treatment. Ingestion: drink milk or gastric lavage and Enema

		with vegetable oil. Medical treatment.
Protective measures	Respiratory protection: Do not need wearing special protection, self absorption filter mask (half mask) is needed in the high concentration exposure Eye protection: Do not need special protection in general; protective chemical safety glasses are needed in high concentration exposure. Body protection: wear anti-static clothing. Hand protection: wear anti - oil resistant gloves. Other: No smoking. Avoid to prolonged or repeated contact.	
Leakage treatment	Evacuate the person in the evacuated area to safe area immediately, and lock the leakage area. Cut off the fire source. The operators should wear the positive pressure self-contained breathing apparatus. Do not touch the leakage directly. Cut off the leakage source to prevent the leakage inflow into the sewer where the space limited. A small amount of leakage: absorb the leakage with soil or non-combustible material or dilute the leakage with water and then treat it with waste water system. A big amount of leakage: cover the leakage with foam to reduce the steam disaster. Transfer the leakage to the exclusive container.	
Store	Store it in the shady, cool and ventilated storeroom. Keep it far from the kindling and heat source. It should separate from the oxidizing agent, acid and alkali metal. The storeroom should use explosion-proof lighting and ventilate facilities. The mechanical equipments and tools which may produce the spark should be forbidden. The store area should stock emergency leakage treatment equipments and suitable container.	

Category	Item	Diesel oil
Physical and chemical properties	Appearance and properties	Colored transparent liquid
	Fusion point	-50-10℃
	Boiling point	200-365℃
	Relative density	0.81-084g/mL at 25 ℃
Combustion and explosion risk	Flashing point	≥45℃
	Self ignition point	350-380℃
	Explosion limit	1.5-6.5（V%）
	Stability	Stable
	Hazardous characteristics	Inflammable，the steam and air can be formed to explosive mixture.
	Extinguishant	Dry powder、Carbon dioxide
The toxicological properties	Toxicity	LD505628mg/kg(Big rat from mouth)；15800mg/kg(Rabbit from skin)；LC5082776mg/kg，4hours (Big rat inhalation)
	Health Hazard	Acute poisoning, anesthetic effect on the central nerve system, mild poisoning symptoms: dizziness, headache, nausea, vomiting. Inhalation of high concentrations of toxic encephalopathy. High concentration of inhalation causes sudden loss of consciousness, reflecting respiratory arrest. May

		cause neuropathy and chemical pneumonia. Respiratory inhalation can cause aspiration pneumonia. Splashed into eyes can cause corneal ulcer, perforation, and even blindness. Skin contact induced acute contact dermatitis, even burn. Acute gastroenteritis caused by swallowing. And can cause liver, kidney damage. Chronic poisoning: neurasthenic syndrome, the plant nerve function disorder, peripheral neuropathy. Severe poisoning encephalopathy.
	Emergency plan	Skin contact: immediately remove contaminated clothing; wash the skin thoroughly with soap and water, medical treatment. Eye contact: filed eyelid, rinse with water or saline, medical treatment. Inhalation: remove to fresh air. To maintain airway patency. If breathing is difficult, oxygen. If not breathing, give artificial respiration, medical treatment. Ingestion: as soon as possible to complete gastric lavage, medical treatment
Protective measures	Engineering controls: airtight operation, ventilation, kindling is strictly prohibited. Body protection: wear anti-static clothing. Hand protection: wear oil resistant gloves.	
Leakage treatment	Evacuate the person in the evacuated area to safe area immediately, and lock the leakage area. Cut off the fire source. The operators should wear the positive pressure self-contained breathing apparatus. Do not touch the leakage directly. Cut off the leakage	

	source to prevent the leakage inflow into the sewer where the space limited. A small amount of leakage: absorb the leakage with soil or non-combustible material or dilute the leakage with water and then treat it with waste water system. A big amount of leakage: cover the leakage with foam to reduce the steam disaster. Transfer the leakage to the exclusive container.
Store	Keep the container sealed, must have the technical measures for fire, explosion, mechanical equipment and tools which are easy to produce the spark are prohibit. It should be paid attention when filling velocity. And a grounding device, to prevent the accumulation of static electricity.

Category	Item	Xylene
Physical and chemical properties	Appearance and properties	Coloreless transparent liquid
	Fusion point	-25.5℃
	Boiling point	144.4℃
	Relative density	0.88 g/mL at 25 ℃
Combustion and explosion risk	Flashing point	25℃
	Self ignition point	463℃
	Explosion limit	1.0-7.0（V%）
	Stability	Stable
	Hazardous characteristics	Inflammable，the steam and air can be formed to explosive mixture. The steam is heavier than air, is able to diffuse far away in the low area, and backdraft by the heat source. It is easy to produce and accumulate the static when the liquid flows quickly.
	Extinguishant	Foam、Carbon dioxide、Dry powder、soil
The toxicological properties	Toxicity	Moderate toxicity.
	Health Hazard	Xylene irritant to skin, mucous membrane, anesthetic effect on the central nervous system; long-term effects can affect the liver, renal function. Acute poisoning: the patient cough, tears,

		conjunctival hyperemia, severe hallucinations, mental confusion, sometimes hysterical attack. Chronic poisoning: neurasthenic syndrome, dry skin, chapped, dermatitis.
	Emergency plan	Skin contact: remove contaminated clothing; wash the skin thoroughly with soap and water. Eye contact: filed eyelid, flush with water flow. Medical treatment. Inhalation: remove to fresh air. To maintain airway patency. If breathing is difficult, give oxygen. If no breathing, provide artificial respiration. Medical treatment. Ingestion: drink plenty of water, emetic. Medical treatment.
Protective measures	The operators are advised to wear the filtration mask (half mask), chemical safety goggles, and antistatic clothing and Rubber gloves.	
Leakage treatment	Evacuate the person in the evacuated area to safe area immediately, and lock the leakage area. Cut off the fire source. The operators should wear the positive pressure self-contained breathing apparatus. Do not touch the leakage directly. Cut off the leakage source to prevent the leakage inflow into the sewer where the space limited.	
Store	Storage in low temperature ventilated place, keep away from fire, heat source. Avoid oxidizing agent. Prohibit the use of easy to produce sparks tools.	

Category	Item	Styrene
Physical and chemical properties	Appearance and properties	Colorless transparent oily liquid
	Fusion point	-30.6℃
	Boiling point	146℃
	Relative density	0.91g/mL at 25 ℃
Combustion and explosion risk	Flashing point	34.4℃
	Self ignition point	490℃
	Explosion limit	1.1-6.1（V%）
	Stability	Stable
	Hazardous characteristics	Inflammable，the steam and air can be formed to explosive mixture. The steam is heavier than air, is able to diffuse far away in the low area, and backdraft by the heat source. In case of fire, high heat and oxidizing agent, there is the risk of combustion and explosion. In case of acid catalyst such as Lewis, Ziegler catalyst catalyst, sulfuric acid, ferric chloride, and aluminum chloride can produce violent polymerization, release a lot of heat.
	Extinguishant	Foam、Dry power、Carbon dioxide、Soil
The	Toxicity	LD50：5000mg/kg(Big rat from mouth)； LC50：

toxicological properties		24000 mg/m3，4hours(Big rat inhalation)
	Health Hazard	Stimulate and narcotize the eyes and upper respiratory tract. Acute poisoning: the high concentration, aroused the eye and upper respiratory tract mucous membrane irritation immediately, eye pain, tears, runny nose, sneezing, sore throat, cough, headache, dizziness, nausea afterwards, vomiting, muscle weakness; punish the person can have dizziness, staggering gait. The eye by styrene liquid contamination can cause burns. Chronic effects: neurasthenic syndrome, headaches, fatigue, nausea, anorexia, abdominal distension, depression, forgetfulness, finger tremor etc. obstructive lung is sometimes caused by disease long-term contact. Rough skin, chapped and thickening.
		Skin contact: remove contaminated clothing; wash the skin thoroughly with soap and water. Eye contact: filed eyelid, flush with water flow. Medical treatment. Inhalation: remove to fresh air. To maintain airway patency. If breathing is difficult, give oxygen. If no breathing, provide artificial respiration. Medical treatment. Ingestion: drink plenty of water, emetic. Medical

		treatment.
Protective measures	The operators are advised to wear the filtration mask (half mask), chemical safety goggles, and antistatic clothing and Rubber gloves.	
Leakage treatment	Evacuate the person in the evacuated area to safe area immediately, and lock the leakage area. Cut off the fire source. The operators should wear the positive pressure self-contained breathing apparatus. Absorb the raffinate with soil or other inert materials and transfer to safe place. Cut off the polluted water and limit the diffusion with oil containment boom. Strengthen the ventilation, to speed up the residual styrene evaporation and drive the steam.	
Store	Storage in low temperature ventilated place, keep away from fire, heat source. Avoid oxidizing agent. Prohibit the use of easy to produce sparks tools. The transport tank trucks should be set grounded chain; partition hole can be set in the tank in order to reduce static electricity generation.	